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Application No. 09/890,695
Filed: August 3, 2001
Group Art Unit: 1754

REMARKS

Claims 1-16 were pending in the instant application. Claim 1 has been amended herein. Accordingly, claims 1-16 will be pending upon entry of the amendments presented herein.

Support for the claim amendments can be found throughout the specification and claims as originally filed. Support for the amendment to claim 1 can be found, at least, for example, on page 4, lines 3-5. No new matter has been added.

Amendments to and cancellation of the claims made herein were done solely to expedite prosecution of the present application, and are not to be construed as an acquiescence to any of the rejections/objections made in the instant Office Action or any Office Actions in the parent application. Applicant reserves the right to further prosecute the claims as originally filed or similar claims in this or one or more subsequent patent applications.

Claim Rejections - 35 U.S.C. §103

Claims 1-6, 9-13 and 15 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nishino et al. (U.S. Patent 4,409,125) taken with Simpson (U.S. Patent 4,274,979).

Applicants respectfully traverse the foregoing rejection.

As presented in the newly amended claim 1, the process according to the invention is the carbonization of a cellulose fiber fabric by passing continuously through a carbonization chamber and retrieving the resulting carbon fiber fabric after carbonization of the cellulose fiber fabric. As the fabric travels continuously through the carbonization chamber, it undergoes consecutive heat treatments at three different conditions. In the first stage, the fabric enters through the

carbonization chamber at a temperature in the range of 250°C to 350°C, at a mean speed lying in the range of 10°C/min to 60°C/min. In the second stage, the fabric undergoes a temperature exposure in the range of 350°C to 500°C at a mean speed in the range of 2°C to 10°C. In the third stage, the fabric undergoes a heat treatment in the range of 500°C to 750°C at a mean speed in the range of 5°C/min to 40°C/min. With the particular combination of temperature and speed, optimal characteristics of the fabric is produced.

In Nishino et al., a process is disclosed for transforming vegetable fibers (including cellulose fibers) into activated carbon fibers. The vegetable fibers are impregnated with a solution containing one element selected from ammonium salts of inorganic acids, nitric acid and boric acid and are subjected to heat treatment to be carbonized and activated in either one step or two consecutive steps. As indicated in Example 1 in Nishino et al. (column 3, line 55, to column 4, line 6), an impregnated fiber cloth is wound up on a roll and introduced into an electric furnace, in a stream of nitrogen gas, at a temperature of 600°C, for a half-hour, at a heating rate of 15°C/min. Similarly, as described in Example 2 (column 4, lines 20-37, Nishino et al.), a raw cloth impregnated with chemicals undergo a heating with an electric furnace at a temperature of 550°C for three-quarters of an hour, at a heating rate of 30°C/min.

Unlike the present invention, Nishino et al.'s carbonization process includes heat at a higher temperature and at a faster rate. Nishino et al. practices a batch process where a single temperature is used. While Nishino et al. describes a range of heating rate from 5°C/min to 15°C/min, preferably 10°C/min to 45°C/min, heating rates of 15°C/min and 30°C/min are provided in

the examples (column 4, lines 4 and 35). Nishino et al. fails to teach or suggest the factors involved for obtaining efficient carbon fiber fabric using a continuous process within a carbonization chamber in accordance with the invention.

In the present invention, three separate heating stages in a continuous manner are performed with variable heating rates that are optimized for shrinkage without an excessive warping of the warp and weft yarn, for a good quality carbonization and for an efficient carbonization time. Additionally, the period of carbonization, in the present invention, requires a slower heating rate at a lower temperature. Nishino et al. fails to teach or suggest any of these novel features of the present invention. Furthermore, Nishino et al. fails to take into consideration the appropriate shrinking of the warp and weft yarn. In the present invention, the first stage of the heating process minimizes the excessive warping of the yarn by applying a faster heating rate (10°C/min to 60°C/min) at a lower temperature (250°C to 350°C). Nishino et al. lacks the teaching or suggestion to all of the combined process components of Applicants' invention as claimed.

Moreover, Simpson fails to cure the deficiencies found in Nishino et al. Simpson describes a fibrous cellulosic material contracted with a Lewis acid and suspended from a frame, which is thereafter positioned within a furnace to carry out carbonization and activation of the cellulosic material. The Examiner asserts that Simpson teaches "the use of a temperature program (column 7, lines 3-16) which uses plural heating rates and holding periods to efficiently carbonize the cellulose fiber" and that "rapid increase has deleterious effects, yet too slow of an increase renders the treatment economically impracticable." While Simpson discloses a temperature program consisting of various temperatures

for a specific amount of time, it fails to disclose the particular combination of desirable temperatures and rates as claimed to obtain the resulting characteristics of Applicants' fabric.

The teachings of Simpson require a relatively low rate of temperature increase during carbonization, namely below 6°C/min, preferably no more than 3°C/min. Otherwise, as taught in Simpson, the carbon fibers obtained tend to be brittle (column 5, lines 53-57). The carbonization process disclosed by Simpson may also include periods during which the temperature is maintained or very slowly increased (column 5, lines 61-65). While Simpson discloses a wide range in temperature (i.e., 20°C to 920°C), the recommended temperatures consist of 100°C, 150°C, 320°C and 920°C. The heating rate as taught in Simpson is clearly distinguishable from the combined heating rates established in the present invention. In contrast to Simpson, the process of the invention undergoes an initial heating rate that is relatively fast, which is inconsistent to the teachings of Simpson. A subsequent heating rate is relatively slower than the first heating rate, but at a higher temperature. In particular, during the carbonization process of the invention, the heating rate is 2°C/min to 10°C/min at 350°C to 500°C. Simpson's requirements are outside the temperature and heating rates of the present invention. The process of the present invention clearly contradicts the teaching of Simpson, either alone or in combination with Nishino et al.

Furthermore, Simpson insists on desirability to maintain a uniform temperature up to the sidewall of the furnace in the region occupied by the suspended fibrous material. This is normally a batch process and contrary to the continuous process of the invention, which requires a temperature gradient along the path of the fiber fabric. The selection of the temperature

profile of the present invention makes it possible to obtain a carbon fabric free of substantial deformation and retention of good mechanical properties and limited duration of the whole carbonization in a continuous (as opposed to batch) carbonization process. Simpson, either alone or in combination with Nishino et al. teaches or suggests the invention as claimed. Accordingly, Applicants respectfully request reconsideration and withdrawal of the foregoing rejection.

Claims 7-8, 14 and 16 are rejected under 35 U.S.C. §103(a) as being unpatentable over Nishino et al. and Simpson as applied to claims 1-6 and 9-13 above, and in further view of Perkins (GB 1,136,349). Applicants respectfully disagree with the foregoing rejection.

As explained above, neither Nishino et al. nor Simpson, either alone of in combination, teaches or suggests the particular combination steps for a continuous carbonization process of a cellulose fiber fabric as claimed. Perkins fails to cure the deficiencies found in either Nishino et al. and/or Simpson. Perkins alone does not teach or suggest a continuous carbonization process on a strip of cellulose fiber fabric travelling through a heat treatment where the heat treatment comprises a temperature profile with a first stage in which the temperature is elevated at a relatively high speed (above 10°C), followed by a second stage in which the temperature is elevated at a lower speed in order to solve the specific problem of obtaining a carbon fiber fabric which is substantially not deformed and keeps good mechanical properties and a third stage where the carbonization involves a faster rate of temperature rise, thereby reducing the total duration of carbonization. Applicants believe that the process as

claimed distinguishes patentably over Nishino et al., either alone or in combination, with Simpson and/or Perkins.

CONCLUSION

Based on the foregoing, Applicant respectfully requests reconsideration of the pending claims and allowance of the application.

The Examiner is encouraged to telephone the undersigned attorney to discuss any matter that would expedite allowance of the present application.

Respectfully submitted,

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